

# Effectiveness of the 585nm Flashlamp-Pulsed Tunable Dye Laser (PTDL) for Treatment of Plantar Verrucae

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**Background and Objective:** The objective of this study was to establish the 585nm flashlamp-pulsed tunable dye laser (PTDL) as a potentially effective modality in the treatment of plantar verrucae. Furthermore, this study attempted to identify if certain regions of the plantar surface yielded a different clearance rate in comparison to others.

**Study Design/Materials and Methods:** Thirty-three patients were recruited for this case series study, representing a total of 97 plantar warts. Patients were treated using the flashlamp-PTDL with a pulse duration of 450  $\mu$ sec, a spot diameter of 5.0 mm, and energy fluences ranging between 8.1 and 8.4 J/cm<sup>2</sup>. Patients were followed-up an average of 2–24 weeks assessing for recurrence of verrucae.

**Results:** Each patient exhibited one to eight plantar lesions. Of the 97 verrucae treated by the flashlamp-PTDL, 68 (70.1%) resolved with 100% clearance of the lesion. The overall mean clearance of the 97 lesions was  $95.1 \pm 16.5\%$ . Of the 97 lesions treated to maximal clearance, 14 lesions recurred after a mean follow-up period of 9.0 weeks.

**Conclusion:** Results of this study have established the 585nm flashlamp-pulsed tunable dye laser as a potentially effective modality treatment of plantar warts. Furthermore, it was determined that there was no significant difference in the clearance rate of warts located at a given plantar site when compared to the clearance rates of the other plantar sites ( $F_{3/44} = 0.58$ ,  $P = 0.634$ ). *Laser Surg. Med.* 21:500–505, 1997. © 1997 Wiley-Liss, Inc.

**Key words:** human papilloma virus; vascular lesions; verrucae

## INTRODUCTION

Verrucae are common flesh-coloured growths of the epidermis, characterized by circumscribed hypertrophy of the corneal papillae, with sclerosis of the Malpighian, granular, and keratin layers of the epidermis. The etiological agent of these benign epithelial tumours consists of at least 60 types of human papilloma virus (HPV) [1].

*Verrucae plantaris* remains one of the most common and challenging dermatologic lesions to treat. Several treatment modalities have been applied in an attempt to eradicate these and other verrucae and have varied from the use of various acids, curettage, cryotherapy, electrocautery, 5-fluorouracil [2], bleomycin, and surgical exci-

sion with the use of a carbon dioxide laser [3]. No single regime has been consistently successful in the eradication of verrucae. Furthermore, many of the stated modalities are not without their own side effects and risks, including scarring, infection [4], bleeding, and pigmentary changes [5] of the skin.

The typical histological appearance of verru-

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cae consists of enlarged and congested vasculature within the dermal papillae [6]. Whereas other modalities of treatment may result in potential morbidity and associated side effects, the PTDL has an advantage in that one can focus the laser energy at the prominent blood vessels in the verrucae. The purpose of this is twofold: (1) the PTDL selectively obliterates the blood vessels to eliminate access of nutrients to the verrucae, and (2) it destroys the most rapidly replicating cells carrying the virus at the basal layer of the epidermis [7]. Furthermore, the ability to focus the energy of the laser directly onto the vasculature diminishes the likelihood of injuring healthy skin tissue [8].

The use of the PTDL at a wavelength of 585nm is also significant. The theory of selective photothermolysis [9] suggests the use of a specific wavelength of light that would be preferentially absorbed by haemoglobin (Hb) relative to other skin chromophores, in particular melanin, the substance resulting in pigmentation of the skin [10]. Wavelengths in the 577–585nm range provide optimal vascular injury without a loss in selectivity [11].

A preliminary study was conducted in an attempt to establish where the PTDL may fit in the current treatment modalities of recalcitrant verrucae [7]. This preliminary work [7] suggested that the PTDL may effectively treat recalcitrant verrucae, the most common being the plantar type. The clearance rates obtained in this study reported 72% of the patient population with complete clearance of their warts, 18% had a 80–95% reduction in their warts, and the remaining 10% had a 50% reduction in wart size [7].

The present study was undertaken to establish the 585nm flashlamp-pulsed tunable dye laser as a potentially effective modality in the treatment of plantar verrucae. Furthermore, this study performed an exploratory analysis to determine if certain regions of the plantar surface yield a significant difference in the clearance rate compared to other plantar regions. Clearance has been defined as the ratio of the size of the wart after the final treatment session to the size of the wart at baseline. Warts found on the softer, more pliable regions of the plantar surface are suggested to respond to the PTDL with greater efficacy. It was therefore speculated that in such regions as the toes and arch of the foot, the laser would be able to penetrate deeper and destroy the vascular supply of the warts more easily. In comparison, areas of the foot that receive greater

pressures (i.e., the metatarsal region and the pad of the foot) would most likely consist of warts that are flattened and surrounded by cornified epithelium, hence making their treatment by laser more difficult than those warts located on the toes and arch of the foot.

## MATERIALS AND METHODS

Patients presenting to the dermatology clinic requesting treatment for plantar warts were asked to participate in this study. Thirty-three patients with plantar verrucae were recruited for this case series study, of which 13 were males and 20 were females. The patients ranged in age from 7 to 56 years. No discrimination with respect to sex or age was made in the selection of the patients for this study.

Upon initiation of treatment, the warts were categorized into one of four plantar regions: toes, metatarsals, arch of the foot, and the pad of the foot. Twelve patients had verrucae of the toes, 19 had verrucae of the metatarsal region, two presented with verrucae on the arch of the foot, and 12 had verrucae located on the pad of the foot. Based on the initial size of the warts and the degree of response to treatment, a number of treatment sessions were required over a period of several weeks to effectively treat the warts to its maximal clearance. Maximal clearance was defined as the point at which laser therapy did not result in further clearance of the lesion. The number of treatment sessions varied among individuals. The time course between treatment sessions varied from 1–4 weeks. During these visits, an assessment of the clearance of the warts was made using clinical and numerical documentation methods. The size of the warts was measured before and after each of the treatment sessions in all patients. In addition, any hyperkeratosis or necrosis of the skin tissue over the area was carefully pared away using a sterile scalpel if required. Caution was taken during debridement to prevent bleeding, since blood would have absorbed the laser energy, thereby preventing the laser light from penetrating deeply into the wart vasculature.

Treatment by the PHOTOGENICA-V (by Cynosure) PTDL involved 3–5 spot-size pulses at a diameter of 5.0 mm per wart (with 50% overlap), a wavelength of 585nm, a fixed pulse duration of 450  $\mu$ sec, and variable energy fluences ranging from 8.1–8.4 J/cm<sup>2</sup>. The patient was supplied with safety goggles during the laser treatment proce-

dure. No other post-operative care was required following each laser treatment session since the epidermis remained intact. Documentation was made of any side effects and/or discomforts such as pain, heat sensation, or scarring.

After treating the site to its maximal clearance, patients were followed-up ranging from 2–24 weeks thereafter to assess for recurrence of any verrucae.

## RESULTS

### Analysis of Data

An average clearance value was calculated along with its associated standard deviation for each of the four plantar regions. In addition, the total number of warts treated was tallied and an overall average clearance in percentage was computed. Clearance was defined as the percent ratio of the size of the wart after the final treatment session to the size of the wart at baseline.

The data was analyzed to determine any regional differences in the clearance of verrucae. An analysis of variance (ANOVA) was performed to determine if there was a significant difference in the clearance rates among the four different plantar regions of the foot, namely, the toes, metatarsals, arch, and pad of the foot. Difference in the degree of improvement in a particular plantar site, when compared to the remaining three plantar sites with each individual, could not be analysed. The number of data points generated to construct a graphical analysis was insufficient. Thus along with a description regarding any significant difference among the four plantar regions of the foot, the data was presented with a descriptive summary of the clearance outcomes for each of the four plantar regions.

Furthermore, recurrence of warts in the different regions of the plantar surface as well as the overall recurrence in all four plantar regions combined was noted. Any associated complications, including bleeding, scarring, or pain were assessed and documented.

### Post-PTDL Exposure and Side Effects

The response of patients to the PTDL was somewhat variable. The majority described the feeling of a pinprick with every pulse of the laser, followed by a sensation of warmth over the treated area for a few minutes. Following laser exposure, most patients reported either no discomfort or mild discomfort that lasted for only a

few hours. Some patients reported mild discomfort lasting for 1 or 2 days. Three patients experienced significant pain lasting for 2 days, which then subsided over the course of the next few days. None of the patients experienced hemorrhage, blistering, infection, hypertrophic scarring, atrophy, pigmentary changes, or prolonged pain as a result of the laser treatment. No long-term side effects were reported by any of the patients.

### Regional Results

Clearance and recurrence data from each plantar region are presented in Table 1.

#### Toes

Of the 12 patients (four males and eight females) representing 27 lesions (warts) of the toes, the mean clearance rate was  $95.6 \pm 10.9\%$ , after a mean of 2.4 treatment sessions over a mean period of 5.2 weeks. Of the 27 lesions treated to maximal clearance, three (represented by 2 patients) recurred after an average follow-up period of 7.9 weeks.

#### Metatarsal Region

Nineteen patients (9 males, 10 females) representing 39 lesions of the metatarsal region were treated with a mean clearance rate of  $91.0 \pm 20.6\%$ , after a mean of 2.5 treatment sessions over a mean period of 5.0 weeks. Of the 39 treated lesions, four (represented by 3 patients) recurred after an average follow-up period of 9.3 weeks.

#### Arch of the Foot

Of the two patients (2 females) displaying two lesions located on the arch of the foot, the mean clearance was 100%, after a mean of 2.5 treatment sessions over a mean period of 5.2 weeks. One of these two warts recurred after a mean follow-up period of 12.5 weeks.

#### Pad of the Foot

Twelve patients (6 males and 6 females) representing 29 lesions found on the pad of the foot were treated with a mean clearance rate of  $94.0 \pm 8.2\%$ , following a mean of 2.8 treatment sessions over a mean period of 4.8 weeks. Of the 29 lesions treated with the PTDL, six (represented by 4 patients) recurred after an average follow-up period of 8.2 weeks.

### Clearance

Among the aforementioned clearance rates for each of the plantar regions, as noted in Table

**TABLE 1. Regional Results of Clearance and Recurrence in the PTDL Treatment of Plantar Warts**

	Overall	Toes	Metatarsals	Arch of the foot	Pad of the foot
# of patients	28	12	19	2	12
# of lesions	97	27	39	2	29
Mean clearance (%)	95.1	95.6	91.0	100	94.0
Mean # of treatment sessions	2.6	2.4	2.5	2.5	2.8
Mean treatment period (weeks)	4.9	5.2	5.0	5.2	4.8
Mean follow-up period (weeks)	9	7.9	9.3	12.5	8.2
# of recurrent lesions	14	3	4	1	6

1, the greatest clearance observed was with those warts located on the arch of the foot. However, one must consider that this category consisted of only two lesions, thereby making any conclusions unreliable. The remaining regions, in descending order of clearance rates, were the toes, pad of the foot, and the metatarsal region. The overall mean clearance for all treated verrucae (97), represented by 28 patients, was  $95.1 \pm 16.5\%$  ( $F_{3/44} = 0.58$ ,  $P = 0.634$ ). Five of the original 33 patients recruited did not continue the study to its completion for such reasons as being dissatisfied with the performance of the PTDL or being unable to provide the required time commitment.

The mean number of treatment sessions for warts in their representative regions varied from 2.4–2.8. The average period of treatment undertaken based on the plantar location, size, depth and resilience of the wart, ranged from 4.8–5.2 weeks. The number of complete laser treatment sessions devoted to each lesion varied since the larger lesions required more treatments with a greater number of overlapping pulses.

### Recurrence

Upon review of the recurrence data, it was noted that of 97 lesions originally treated to maximal clearance, 14 recurred after a mean follow-up period of 9.0 weeks. The recurrence data varied to some extent upon examination of the results for each plantar site. Of the 27 lesions of the toes, three reappeared after being followed-up for an average period of 7.9 weeks. There were four recurrent lesions out of the 39 metatarsal lesions after being followed-up for an average of 9.3 weeks. One out of the two lesions of the arch of the foot recurred following a 12.5 week follow-up. Finally, of the 29 warts situated on the pad of the foot, six reappeared after an average follow-up of 8.2 weeks.

Nevertheless, of the 97 verrucae treated by the PTDL, 68 (70.1%) resolved with 100% clear-

ance after a mean follow-up of 9.0 weeks. The majority of the remaining warts had clearance rates ranging from 80–95%.

### DISCUSSION

The natural history of verrucae is extremely variable from one patient to another. A wide variety of treatment modalities have arisen in the past two decades, none of which have proven to be entirely successful. This variable response has made it difficult for dermatologists to treat verrucae. Dermatologists are therefore forced to employ many different modalities of treatment in an attempt to identify the most beneficial mode of treatment for each patient. In some instances, a wart may spontaneously regress without any intervention, whereas in other cases, a wart may persist despite attempting a variety of treatment modalities.

In addition to the clearance rates, significant aspects of each modality must be considered. These include the morbidity, side effects, and the long-term prognoses associated with these treatment methods. The ability of a certain method of treatment to produce consistent results is also an important element to consider.

Due to the fact that plantar verrucae are difficult to treat [5], this study sought to establish whether or not certain regions of the plantar surface had a higher propensity to clearance of warts using the PTDL. This was investigated by dividing the plantar surface into four generalized regions. Based on the results illustrated in Table 1 and the statistical analysis, we could not confirm or dispute the original hypothesis that warts found on the softer, more pliable regions of the plantar surface (i.e., toes and arch of the foot) would respond to the PTDL with greater efficacy. There was no statistically significant difference in clearance rates among the four plantar regions ( $F_{3/44} = 0.58$ ,  $P = 0.634$ ); however, it was discov-



ered that all plantar regions had clearance rates > 90%. The original explanation that the laser will be able to penetrate deeper and destroy the vascular supply of the verrucae with greater ease should not be dismissed. The number of warts treated in this study were insufficient to make such a determination.

The precise reasoning for the apparent success of this laser treatment is unknown, but several theories have been suggested [7]. The selective concentration of laser energy to the vasculature of the skin results in its destruction, followed by a process of necrosis of the wart. Perhaps the heat-sensitive nature of the HPV is what allows the thermal energy of the laser to eradicate the virus so successfully [12].

Given the known persistence and resilience of warts and their propensity to recur, it was not surprising to note that of the 97 lesions treated, 14 (14.4%) had recurred after an average follow-up period of 9.0 weeks. It was also noted that the pressure-receiving point of the foot (i.e., mainly the pad of the foot) experienced a greater recurrence rate (20%). Perhaps the reason for this recurrence is because the responsible agent (the human papilloma virus, HPV) seeds itself deeper in areas where pressures are greater. If this is in fact true, one also would have expected to see a higher recurrence rate with warts on the metatarsal region (10%) in comparison to the warts found on the toes (11%), since it was also a pressure-receiving region. In this study the recurrence rates between these two regions were similar. Clearly, a larger population size in this study would be required to make any conclusive statements regarding the relationship between recurrence rates of warts located on pressure-receiving points of the foot to those located elsewhere on the plantar surface.

This study has produced results similar to that seen in recent literature [7]. Several articles studying the use of the PTDL in the treatment of various dermatological lesions have reported minimal to no side effects, such as scarring, bleeding, pain, abscess formation, and infection [7,8,13–16]. This aspect of the PTDL was confirmed during this investigation, thereby making it a potentially more attractive mode of treatment for warts. Nonetheless, there were three patients in this study who experienced severe pain that lasted for 2 days. The pain noted by these patients was concerning given that previous studies [7] reported that no pain was experienced by any of their participants. Since the future success of a

potential treatment modality of plantar warts is highly dependent upon patient comfort and compliance, careful investigation is necessary to determine the pain response to the PTDL.

The PTDL parameters applied were as follows: energy fluences of 8.1–8.4 J/cm<sup>2</sup>, a laser spot diameter of 5.0 mm, and a pulse duration that was fixed at 450  $\mu$ sec. These parameters have been used commonly in the treatment of various dermatological lesions, including verrucae [7,14–17], and were therefore used in this study. Future studies may focus on altering the various PTDL parameters to note any specific histopathological changes that may lead to greater efficacy rates.

This study specifically focused on the treatment of plantar verrucae only, since it remains one of the most difficult type to treat. Plantar verrucae are more debilitating than those located at other sites. As such, the removal of plantar verrucae with the PTDL is potentially beneficial in reducing the morbidity of this skin lesion.

The variability in the duration of the follow-up period can be attributed to noncompliance of patients in being able to appear to the dermatology clinic for their follow-up assessment at the appropriate time interval. Therefore, each patient was reassessed post-PTDL treatment at a time that was mutually agreeable between the patient and the investigators.

The variation seen in the number of treatment sessions and the duration of treatment was due to such reasons as disparity in the depth, location, and size of the warts and also due to noncompliance of patients keeping their scheduled appointment. Furthermore, some warts were simply more resistant to treatment than others and, therefore, required a greater number of treatment sessions over a greater duration of time. There appeared to be no single dominant factor that dictated why certain warts required a greater number of treatment sessions than others; the reason is most likely to be multifactorial.

Although the clinical results, with an overall mean clearance rate of 95.1%, are promising, one cannot conclude with certainty that the PTDL can be applied as one of the optimal treatment modalities for verrucae plantaris. Upon comparison between the effectiveness of the PTDL to that of using standard dermatological modalities, such as CO<sub>2</sub> laser therapy, cryotherapy, and bleomycin sulfate, which have commonly been reported to be ~75% effective [17], the results achieved from this report suggest that the PTDL cannot be overlooked as a potential method of treatment of plan-

tar warts. It would be ideal to engage in a larger randomized control study to establish where such a new treatment may fit into the current class of standard treatment modalities.

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